

Recent Innovations in the Virginia Dam Safety Program

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INTRODUCTION

The Virginia Dam Safety Program has introduced and adopted several innovative programs to improve dam safety and assist dam owners in meeting the requirements of minimum public safety standards for more than 2,000 regulated dams, including 400 high-hazard dams. Most of the dams in the program are privately owned. Each innovation was initiated to help solve a specific problem identified in the program, to improve existing operations, or to address other dam owner needs. The dam safety program, managed by the Virginia Department of Conservation and Recreation, is focused on these innovations to improve dam safety and to assist dam owners with these challenges.

- A. Dam Dragnet** aims to locate all dams of regulated size in Virginia. The need for Dam Dragnet arose from a change in the state's size criteria of a regulated impounding structure.
- B. Dam First Aid** assists dam owners with emergency repairs by providing trailers with siphon equipment to lower lake levels.
- C. Dam Watch** helps dam owners prevent loss of life and property damage from a dam failure by increasing dam break warning times with alerts of significant rainfalls and earthquakes affecting their dams.
- D. Low-Cost Simplified Inundation Mapping** helps owners of low-hazard dams obtain required dam break inundation models and maps for hazard determination and emergency action plans.
- E. Hazard Creep Prevention** helps keep low-hazard and significant-hazard dams from being reclassified as high-hazard by restricting downstream development.
- F. A New Statewide Probable Maximum Precipitation (PMP) Study** will provide more accurate storm data to base emergency spillway requirements, and potential remediation of high-hazard and significant-hazard dams.

INNOVATIONS

A. Dam Dragnet

Before 2002, the Code of Virginia defined a regulated impounding structure as a dam 25 feet or greater in height with an impoundment capacity of 50 acre-feet or greater. The definition was changed in 2002 to all dams that are 25 feet or greater in height that create an impoundment capacity of 15 acre-feet or greater, and all dams that are 6 feet or greater in height that create an impoundment capacity of 50 acre-feet or greater. As a result, a significant increase in the number of regulated dams occurred. Without additional resources and staff, only a limited effort could be made to locate these newly regulated dams.

Dam Dragnet was developed to systematically scan the state and locate regulated size dams using GIS software and the US Geological Survey (USGS) National Hydrography Dataset, which was recently updated by the Virginia Department of Transportation. An initial list was created of about 6,000 water bodies with a surface area greater than 1.5 acres. The threshold of 1.5 acres was estimated to capture water bodies that may be of regulated size. Existing dams in our database were crosschecked with the water bodies list to avoid duplication.

Scanning aerial photographs confirms locations and areas of water bodies of potentially regulated impounding structures. Recognizing the limitations due to variable accuracy of topographic data, the height of the dam is estimated. This approach is limited because Virginia has LiDAR based topography only for coastal areas.

Dam ownership is determined by searching land and tax records that are available online from some counties and cities. However, without such online data, visits to courthouses are required.

Finally, for those impounding structures that appear to be of regulated size, a site visit is made to confirm the height and capacity. The owner is notified if the impounding structure is confirmed to meet the regulated size criteria of the Code of Virginia, and the requirements for meeting minimum public safety standards are explained so the owner can obtain either a Conditional Operation & Maintenance Certificate, or a Regular Operation & Maintenance Certificate.

In one of five regions of Virginia where Dam Dragnet is almost complete, the number of regulated dams increased from 211 to 578 dams. Virginia Tech interns have contributed to the success of the Dam Dragnet program.

B. Dam First Aid

About 70% of dam failures are caused by flood or overtopping (Source: Table 4-1: Causes of Dam Failure 1975-2011, *Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incident Failures*, FEMA P-946 / July 2013). Dam failure may be prevented in some cases of extreme weather by taking an operational action prior to a heavy storm, such as lowering the reservoir to increase the storage capacity, thereby potentially preventing an overtopping failure. Siphoning is often the only means to lower the water level for repairs of nonfunctional drains that may also prevent overtopping and potential dam break.

As a result of the Dam First Aid initiative, four trailers are equipped and located around the state in Virginia State Parks for dam owners to access for this purpose and to lower the water level for emergency repairs or otherwise address a potential dam break. For owners to utilize the trailers, training and supervision by a Dam Safety Engineer

is required; however no fee to the dam owner is required, except for replacement of consumables. The cost of the trailers and equipment was about \$10,000 per trailer.

The trailers are equipped with an array of equipment:

- PVC pipe (6"), fittings, and valves for siphons to lower water level
- Trash pump and hoses for priming siphons
- Generator and flood lights
- Tools and safety equipment

C. Dam Watch

Dam Watch is a real-time, web-based, dam break early warning system for high-hazard and significant-hazard dams that collects data from live sources/feeds such as the National Oceanic and Atmospheric Administration, National Weather Service (NWS), Natural Resources Conservation Service (NRCS), and USGS. The data is then compared against predetermined thresholds and, if warranted, alerts or other notifications are issued. Warnings and alerts are distributed immediately to dam owners and emergency responders via electronic media (email, cell phone text messaging, fax, etc.) according to client-defined specifications or emergency action plans. The warnings may be used by dam owners to protect their dams during heavy storms by taking actions such as lowering water level or modifying the operation of the dam to provide emergency responders with time to evacuate the dam break inundation zone and protect downstream lives at risk from a failure.

Delineated shape files of the watershed for each dam allow the program to total the rainfall from the Nexrad weather data and compare to the triggers set for the warnings and alerts. Owners



One of Virginia's four "Dam First Aid" trailers. Notice the siphon in the background.

also receive NWS warnings, USGS stream gauge data, onsite dam instrumentation data if available, and USGS earthquake data. The web-based system also provides access for dam owners and emergency responders to digital emergency action plans, dam break inundation maps, plans, inspection reports and other data on each dam.

US Engineering Solutions developed and maintains Dam Watch as a service to Virginia, other states, and NRCS. The cost of the Dam Watch service is about \$66 per dam per year. As a service to dam owners and improvement to public safety in Virginia, there is no charge to dam owners.

D. Simplified Inundation Mapping

The Code of Virginia requires all dam owners to have a licensed professional engineer prepare a dam break inundation analysis and map. The following scenarios must be considered:

1. Sunny day dam break
2. Spillway design flood with dam failure
3. Spillway design flood without a dam failure
4. Probable Maximum Flood (PMF) with dam failure

To reduce the cost to dam owners, the Virginia Dam Safety Program offers a simplified inundation mapping service to determine whether the dam has a low-hazard-potential classification. Models used for the simplified inundation mapping included initially GeoDam Breach and DSAT Wise, but due to their limitation to sunny day

break, we now use HEC-1, HEC-HMS, HEC-GeoRAS, and ArcMap 10.1 to provide more accurate mapping to dam owners. Sunny day break, full PMF with and without dam failure are mapped to show the worst case scenarios.

The analysis is based on available information. On completion of the analyses and dam break inundation map, Dam Safety notifies the dam owner if the hazard classification is low or not and the requirements to be compliant with the Dam Safety Act and Regulations. If the dam is determined to be low-hazard, the owner is eligible for a simple general permit with minimal requirements. The dam owner must submit the dam break inundation map to the locality. If the dam is determined to be high-hazard or significant-hazard, the dam owner is required to provide a full dam break inundation analysis and map prepared by their licensed professional engineer.

E. Hazard Creep Prevention

As a result of development downstream of dams, many low- and significant-hazard dams can become high-hazard dams, a process referred to as hazard creep. These dams that were designed with lower emergency spillway capacity based on their original hazard classification must be rehabilitated to meet increased spillway capacity required by the higher hazard classification. The dam owners, by no fault of their own, are now faced with significant costs for engineering and construction of an increased capacity emergency spillway.



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In order to reduce hazard creep, the Virginia General Assembly passed legislation entitled “Requirement for Development in Dam Break Inundation Zones.” For any development proposed within the boundaries of a dam break inundation zone that has been mapped, the locality shall:

- Review the dam break inundation zone map on file with the locality for the affected dam
- Notify the dam owner
- Request Dam Safety make a determination of the potential impacts of the proposed development on the spillway capacity required for the dam.

If Dam Safety determines the plan of development would change the spillway capacity required of the dam, the locality shall not permit development or redevelopment in the dam break inundation zone unless the developer agrees to change the plan so it does not require an alteration of the spillway capacity of the dam, or the developer contributes payment up to 50% of the cost to upgrade the dam.

Since these requirements shall not apply to any development proposed downstream of a dam for which a dam break inundation zone map is not on file with the locality at the time of the official submission of a development plan to the locality, the importance of completing and submitting the inundation map to the locality is critical for the dam owner.

F. Probable Maximum Precipitation Study

In 2014, the Virginia General Assembly, concerned with the high cost of rehabilitation to dam owners, proposed legislation to suspend the Dam Safety Act and Impounding Structure Regulations for a period of one year to allow for a study of the impact of these regulations on costs to dam owners. Since such a suspension would have an impact on public safety by suspending dam safety inspections, emergency action plans and updates, tabletop exercises, dam break inundation modeling and mapping, and hazard classification, the department proposed an alternative.

The major cost for many owners of significant- and high-hazard dams is for the rehabilitation of their emergency spillways to meet capacity requirements based on the PMP and resulting PMF. Emergency spillways of new high-hazard dams are required to have the capacity to safely pass the PMF. Existing high-hazard dams are required “to pass a rainfall event greater than the maximum recorded within the Commonwealth, which shall be deemed to be 90% of the maximum precipitation,” and existing significant-hazard dams are required to pass 50% of the PMF.

Therefore, the department made a proposal to legislators to maintain public safety requirements for dams and to address the costs to dam owners for spillway rehabilitation. Since several other states have recently completed new PMP studies that have reduced PMP values from 5% to 50%, there is the potential that a new Virginia PMP



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study may also reduce PMP values, which may reduce or eliminate costs to dam owners for emergency spillway rehabilitation for high and significant-hazard dams. As the existing PMP data for Virginia is about 40 years old, additional storms are available to be analyzed, and modern tools and methodologies can be employed.

The General Assembly introduced, and the Governor signed on April 1, 2014, legislation that authorized a new Virginia PMP Study to be completed by December 1, 2015. The legislation allows that “owners of impounding structures with spillway design inadequacies who maintain coverage under the conditional certificate are not required to rehabilitate the spillway until the PMP analysis is completed and reviewed by the Virginia Soil and Water Conservation Board.” On May 2, 2014, a contract was signed with Applied Weather Associates for the Virginia PMP Study. A review panel of experts and cooperating state and federal agencies was established by Dam Safety to provide advice and expertise throughout the study. Other states that have had PMP studies done have also established review panels for participation by partners and stakeholders.

CONCLUSION

Innovations in the Virginia Dam Safety Program are designed to improve public safety and reduce costs for dam owners. Dam Dragnet assists owners by informing them that their dam is regulated and of their responsibilities. Dam First Aid helps dam owners by lowering water level for emergency repairs. Dam Watch provides early warnings to dam owners responsible for protecting downstream residents. Low-Cost Simplified Inundation Mapping provides owners with their hazard classification and map for developing their Emergency Action Plan. Hazard Creep Prevention protects low-hazard dam owners from increasing hazard classification with higher costs and may prevent downstream residents from building in dam break inundation zones. A new statewide PMP study will provide dam owners with more accurate data for design of spillway capacity rehabilitation for safer dams, and potentially a reduction in rehabilitation costs.

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